# COAL PROCESSING VIA SOLVENT EXTRACTION

**Presented at**

**The Direct Carbon Fuel Cell Workshop**

**July 30, 2003**
**NETL - Pittsburgh, PA**

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# THE NEED

- **Convert coal to a suitable fuel for use in the direct carbon fuel cell**

  - **The problem: coal contains ash and sulfur.**

    - **Ash contaminates the electrolyte**
    - **Sulfur degrades the electrodes**

# THE CHALLENGE

**To produce a suitable feedstock for the direct carbon fuel cell from coal, we must:**

- **Reduce the mineral matter content**
- **Reduce the sulfur content**
- **Reduce the volatile matter**
- **Control the microstructure**

# THE SOLUTION

## Reduce Mineral Matter

- **Use Solvent Extraction -**
  - **Organic solvent (NMP) dissolves organic matter in coal and leaves behind mineral matter (ex. sugar and sand)**
  - **Reflux at 202°C for 1 hour**

**Aside - as mineral mater is removed, heating value increases**

**ex. Raw Coal ~ 12,500 BTU/lb**
**Extract ~ 14,500 BTU/lb**

# Mineral Matter Reduction
# (as ash)
# WVGS Coals

| | WVGS 13425 | WVGS 13423 | WVGS 13407 | WVGS 13421 | WVGS 13424 | WVGS 13422 | WVGS 13426 |
|---|---|---|---|---|---|---|---|
| % Extract Yield | 25.0 | 34.2 | 66.3 | 63.1 | 27.7 | 25.0 | 21.4 |
| % Ash in Raw Coal (Dry) | 6.3 | 4.3 | 16.1 | 3.2 | 12.4 | 6.5 | 8.2 |
| % Ash in Extract (Dry, filtration) | 0.2 | 0.3 | 0.2 | 0.1 | 0.2 | 0.2 | 0.3 |
| % Ash in Extract (Dry, Centrifugation, Filtration) | | | | 0.04 | | | |

# THE SOLUTION

## Reduce Sulfur

- Sulfur in coal exists as
  - organic sulfur
  - inorganic sulfur

- Solvent extraction removes all inorganic sulfur and some organic sulfur

- Select coal with predominately inorganic sulfur

ex. Bakerstown Coal:

Raw Coal - 4% overall sulfur

Extract - 1% organic sulfur

# THE SOLUTION

## Reduce Volatile Matter

- Extract contains about 25% volatile matter

- Can be easily removed by "coking" and "calcining"

  i.e. heat to ~ 500°C in inert atmosphere (coking)
  i.e. heat to ~ 1300°C in inert atmosphere (calcining)

ex. Arch Coal Sample:
VM Raw coal = 32%
VM Green Coke = 6.2%
VM Calcined coke = 0%

# THE SOLUTION

## Control Microstructure

- Raw extract yields disordered or "turbostratic" carbon
- Can hydrotreat raw coal to yield very anisotropic carbon
- Can blend raw and hydrotreated extracts to tailor microstructure
- Heat treatment of the coke can alter the microstructure.

# USE OF THE RESIDUE

- As a boiler fuel blended with low-ash coal
- As a gasification feedstock - Hydrogen production
- As a source material for activated carbon
- As a catalyst/catalyst support

# ECONOMICS

**Mitre Corporation performed an initial cost estimate on the basic extraction process.**

- **Cost of Production:**
  - **~$80/ton for raw coal**
  - **~$174/ton for calcined extract**

- **Cost Based on Heating Value:**
  - **$2.76/Million BTU for extract**
  - **$6.00/Million BTU for calcined extract**

# SUMMARY

- Solvent extraction is a viable mechanism to clean coal for the carbon fuel cell
- Ash and Sulfur can be reduced
- Structure can be controlled
- Preliminary economics look favorable
- Samples are available for evaluation